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NATIONAL DAM SAFETY PROGRAM. KIRKWOOD LAKE DAM (NJ-00399). DELA--ETC(U)
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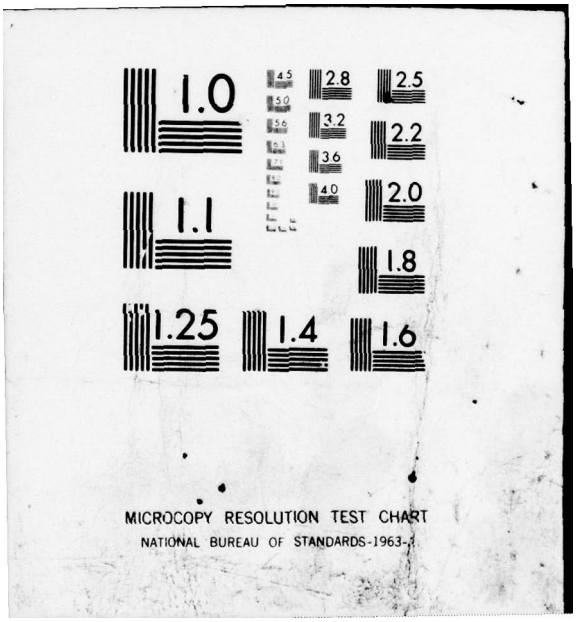
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DELAWARE RIVER BASIN
COOPER RIVER, CAMDEN COUNTY
NEW JERSEY

KIRKWOOD LAKE DAM
NJ 00399

LEVEL II

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Kirkwood Lake Dam (NJ-00399), Delaware River Basin. Cooper River, Camden County, New Jersey. Phase 1 Inspection Report.

(9) Final rept.,

(10) F. Keith /Jolls

(15) DACW61-79-C-0011

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

(11) August, 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Kirkwood Lake Dam Camden County, N.J.		5. TYPE OF REPORT & PERIOD COVERED FINAL 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Jolls, F. Keith P.E.		8. CONTRACT OR GRANT NUMBER(s) DACW61-79-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS Louis Berger & Associates 100 Halstead Ave. East Orange, N.J. 07019		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, Pennsylvania 19106		12. REPORT DATE August 1979 13. NUMBER OF PAGES 35
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16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Kirkwood Lake Dam, N.J.	Dams
Spillways	Visual Inspection
Slopes	Structural Analysis
Outlet Works	National Dam Inspection Act Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, NJ 08621

25 SEP 1979

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Kirkwood Lake Dam in Camden County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Kirkwood Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 26 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the One Hundred Year Flood). To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within thirty days from the date of approval of this report, the ownership and responsibility for maintenance should be clarified as a collapse could present a legal problem regarding responsibility.

c. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The low level outlet should be made operable so that the reservoir can be drained.

(2) The downstream slopes of the dam embankment in the vicinity of the bridge wingwalls should be regraded, compacted and topped with suitable slope protection.

(3) The trees should be removed from the dam crest in the vicinity of the spillway and the disturbed areas regraded, compacted and seeded.

(4) Heavy stone should be placed in the downstream stilling basin in selected areas to prevent further scouring and preclude the undermining of the bridge structure.

(5) Patch the spalled and deteriorated concrete surfaces and stone masonry of the bridge walls.

(6) The crest width should be increased at each side of the spillway and seeded or protected from surface erosion.

(7) The owners should upgrade the operation and maintenance procedures for the dam by utilizing a check list for periodic inspections and instituting a system of record keeping for severe storms.

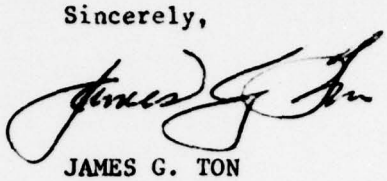
A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman James J. Florio of the First District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

KIRKWOOD LAKE DAM (NJ00399)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 1 May 1979 by Louis Berger & Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Kirkwood Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 26 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the One Hundred Year Flood). To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within thirty days from the date of approval of this report, the ownership and responsibility for maintenance should be clarified as a collapse could present a legal problem regarding responsibility.

c. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The low level outlet should be made operable so that the reservoir can be drained.

(2) The downstream slopes of the dam embankment in the vicinity of the bridge wingwalls should be regraded, compacted and topped with suitable slope protection.

(3) The trees should be removed from the dam crest in the vicinity of the spillway and the disturbed areas regraded, compacted and seeded.

(4) Heavy stone should be placed in the downstream stilling basin in selected areas to prevent further scouring and preclude the undermining of the bridge structure.

(5) Patch the spalled and deteriorated concrete surfaces and stone masonry of the bridge walls.

(6) The crest width should be increased at each side of the spillway and seeded or protected from surface erosion.

(7) The owners should upgrade the operation and maintenance procedures for the dam by utilizing a check list for periodic inspections and instituting a system of record keeping for severe storms.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 22 Sep 1979

PHASE 1 REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Kirkwood Lake
Fed. ID# 00399

State Located New Jersey
County Located Camden
Coordinates Lat. 3950.2 - Long 7500.1
Stream Cooper River
Date of Inspection 1 May 1979

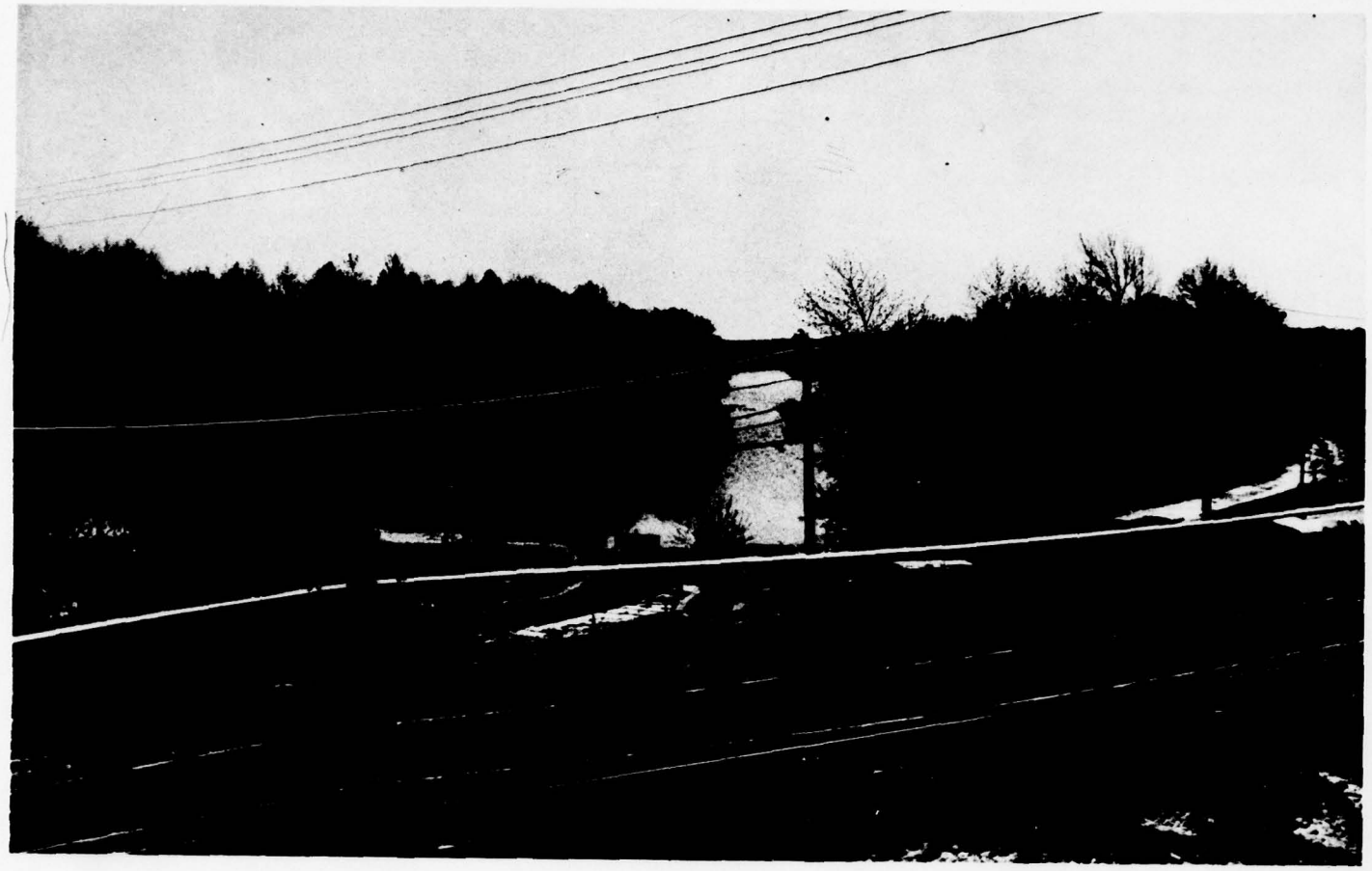
ASSESSMENT OF GENERAL CONDITIONS

Kirkwood Lake is assessed to be in an overall fair structural condition and is recommended to be downgraded from a high hazard to a significant hazard category. Overtopping of the dam would not appreciably increase the danger of loss of life or property damage as the downstream flood plain is, for the most part, uninhabited. No detrimental findings were covered to render a questionable judgement as to the structural stability. Remedial actions recommended to be undertaken in the near future are to 1) regrade slopes adjacent to wingwalls, 2) remove root systems on the embankment slopes by the spillway, 3) place riprap in the downstream channel, 4) patch the concrete and masonry surfaces of the bridge substructure, and 5) rebuild the dam crest width at each side of the spillway and seed or provide erosion protection.

The ownership of the dam could not be determined.

This dam has an inadequate spillway, being able to accomodate only 25% of the spillway design flood.

F. Keith Jolls P.E.
Project Manager



OVERVIEW OF KIRKWOOD LAKE DAM

MAY, 1979

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APPENDIX

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM: KIRKWOOD LAKE DAM FED ID# NJ 00399

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with Contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The State, in turn, is under agreement with the U.S. Army Engineer District, Philadelphia, to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Kirkwood Lake Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

The dam at Kirkwood Lake is a straight 250 foot long, ill-defined low earth embankment with a rectangular concrete box spillway built into an ancient stone masonry bridge abutment near the left end of the dam. The hydraulic drop at the 11' x 19' spillway is 8.5' and discharges into an irregular stilling basin adjacent to the R.O.W. of the PATCO commuter railroad (Pennsylvania Reading Seashore Railroad).

b. Location

Kirkwood Lake Dam is located on the Cooper River 0.30 mile northeast of the intersection of White Horse Road (Rt. 673) and White Horse Pike (Route U.S. 30) on the municipal boundary between the Township of Voorhees and Borough of Lindenwold, Camden County.

c. Size Classification

The maximum height of the dam is 12.5 feet and the maximum storage is estimated to be 226 acre-feet. Therefore the dam is placed in the small size category as defined by the Recommended Guidelines for Safety Inspection of Dams (storage less than 1,000 acre-feet and height less than 40 feet).

d. Hazard Classification

Based upon the Corps of Engineers criteria and the fact that in the event of a failure, little damage would be inflicted on downstream development or endanger human life, the classification is recommended to be downgraded to a significant hazard. Below the dam, Cooper River flows under White Horse Road in an elliptical corrugated culvert which would act as a hydraulic restriction to downstream flooding. The roadway embankment (some 100 feet downstream) would actually function as a back-up dam. Its average height is 10 to 20 feet above the study dam crest. Further downstream, the flood plain is only sparsely developed with most facilities above expected high water, except for a sewage treatment plant. However, a failure of the spillway could block the elliptical CMP under White Horse Road and possibly flood the adjacent railroad trackage of the PATCO commuter line. In view of the potential damage to this utility, the significant hazard classification is hereby recommended.

e. Ownership

The legal owner is presently unknown. Both the muncipalities of Voorhees and Lindenwold and Camden County disclaim ownership. According to Dam Application 31-35 (dated 5/20/43) the structure is owned by the Kirkwood Lake Colony Club of Kirkwood N.J. but they could not be located. In 1966, a Mr. Albert N. Brewin wrote to the Department of Conservation and Economic Development requesting permission to make minor repairs but there is no record that he owns the dam.

f. Purpose of dam

The dam was built to impound a recreational lake within a lakeside residential development.

g. Design and Construction History

It is unknown when the earliest dam at this site was initially constructed. The present spillway was rebuilt by the Lakeside Park Development Company in 1941 after the dam embankment had been breached by the flood of September 1, 1940. Historical records indicate the spillway was relocated from the right to the left end of the dam and the dam was initially constructed in 1931 or 1932 by the American Ice Co. The 1941 reconstruction plans were prepared by Paul X. Blattler, P.E. #1977 but only indicated the spillway details. Except for periodic replacement of timber stoplogs, the basic configuration has apparently not changed since 1941.

h. Normal Operating Procedures

The dam spillway functions as an uncontrolled weir with no attempt to control the reservoir level except during periods of cleaning and repair (see Section 4).

1.3 PERTINENT DATA

a. Drainage Area - 5.14 sq. miles

b. Total spillway capacity at maximum pool elevation 918 cfs.

c. Elevation (above M.S.L.)

Top of dam - 59.81
Recreation Pool - 55.81
Streambed at center line of dam - 47.3±

d. Reservoir

Length of Recreation Pool - 3700 feet
Length of Maximum pool - 4200 feet

e. Storage

Recreation Pool - 92 acre-feet
Top of Dam - 226 acre-feet

f. Reservoir Surface

Top of dam - 36 acres
Recreation pool - 31 acres

g. Dam

Type : Earth embankment with 3 sided concrete drop inlet spillway.

Length - 250 feet
Top Width - 20 feet
Height - 12.5 feet
Side Slopes - 2H:IV±
Zoning - Unknown

h. Diversion and Regulating Tunnel

None

i. Spillway

Type - Three-sided overflow concrete box
Length of weir - 41 feet

j. Regulating Outlets - removable stoplogs in spillway (3' x 3' and 3' x 5') See Figure 4.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The only information available for design review were microfilm records and the single drawing prepared in 1941 for reconstruction of the spillway. This indicated the geometry and details of this wall section but revealed nothing of the earlier highway bridge to which the spillway is connected. Also located were several hydraulic calculations which were reviewed (as summarized in Section 5). No boring logs or information were available although it was indicated on the 1940 Dam Application that the underlying foundation material is a fine sand with a trace of clay and a dark impervious green marl. The general area is surrounded by stratified marine sands known as Kirkwood deposits which contain fine micaceaous quartz sand with varying amounts of silt. The depth to bedrock in this area is greater than 100 feet.

2.2 CONSTRUCTION

Little information was obtained regarding the 1941 construction. From the various reports at that time, the construction appeared to have been accomplished substantially in agreement with the design. There have been no other major structural modifications since the 1941 work.

2.3 OPERATION

There is no day-to-day operation at this dam as the timber stoplogs are kept continuously closed under normal conditons. The lake level is uncontrolled except during periods of maintanence.

2.4 EVALUATION

a. Availability

Sufficient engineering data is vailable (except for the old spillway bridge) to ascertain the structural stability and assess the dam's

overall safety. No data was located upon which to base an assessment of the embankment permeability but in light of the modest height, the dike structure appears to be stable.

b. Adequacy

It is felt that the available data is sufficient to allow the rendering of the following assessment contained in Section 7.

c. Validity

The validity of the information available is not challenged and is accepted without recourse to further investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

The visual inspection was conducted on May 1, 1979 at which time the inflow was producing a modest discharge over the spillway. The physical condition of the embankment appeared stable and the inspection team was primarily concerned with the deteriorated condition of the old spillway bridge.

b. Dam

The embankment appears to have supported a local street in earlier times and is fairly wide in comparison to its height. However, it is only about 13 feet wide at the spillway. The old stone masonry bridge at the spillway previously supported a steel I-beam and timber deck (now removed). The upstream edge of the dam crest is lined with small trees and the entire downstream slope area to the right of the spillway has been backfilled to only one foot below crest grade. There is a considerable amount of scouring at the ends of the wingwalls. The left abutment zone contains a much newer concrete headwall and storm drain discharge pipes from the railroad switching yards on the south side of the lake. There has apparently been little upkeep of the embankment slopes for many years. Much of the dam crest is much wider than the 20 feet indicated in the design plans but is completely devoid of vegetation. It was noted that the roadway embankment of County Road 673 (in the vicinity of the downstream slope toe) is much higher than the dam embankment (about 25 feet just below the spillway) and effectively forms an additional embankment structure roughly paralleling the main embankment axis.

c. Appurtenant Structures

The three-sided concrete spillway is in a satisfactory condition with only minor cracking and surface spalling but the stone masonry walls of the older highway bridge immediately below the spillway are in an advanced stage of deterioration. The original ashlar masonry has been repaired with concrete blocks which have pulled loose and the mortar joints are open. The concrete wingwalls are only vestiges of their original shape with many parts missing or broken loose from their supports. The sharp-crested weirs on the spillway were submerged and could not be examined closely but the crest appears level with no evidence of differental settlement. Several new timber stoplogs have been recently installed in the sluice ways on each side of the inlet. It could not be determined how the stoplogs are removed from the lower righthand opening. The small steel I-beams which formerly supported the bridge deck slab are rusty and add only secondary lateral support to the abutment walls.

There are several sections of small water mains in and around the spillway but it could not be determined if any were operable.

d. Reservoir

Kirkwood Lake has a well-established shore line with numerous homes along the north boundary. On the south, the storage and switching yards of the PATCO commuter line occupies much of the frontage. The lake is clear of debris up to its headwaters where Cooper River and Millard Creek jointly feed the reservoir. It was noted that there are several small dams immediately upstream (see Section 5).

e. Downstream Channel

The dicharge from the dam flows through a 8' x 15' elliptical C.M.P. culvert under

the Route 673 embankment. The channel runs parallel to the railway embankment and is straight and fairly clear of obstructions. However, it makes a sharp left turn approximately one-tenth of a mile downstream from the highway and passes through a bridge under the railroad. The railroad bridge has a rectangular opening with a span of 21 feet and a height of opening to water surface of 5 feet. Further downstream the highway culvert under Chews Landing Road is almost completely silted up. The only facility in the downstream flood plain is a sewage disposal plant 1.3 miles below the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operational procedures were not observed by the inspection team. As the present owners could not be located, maintenance responsibility or operational procedures undertaken in the past (except for dewatering the lake several years ago) remain unknown.

4.2 MAINTENANCE OF DAM

There has apparently been little or no continual maintenance of this dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operational facilities are the two stop-log gates in the sides of the spillway. It appears they are opened only during de-watering operations for reservoir maintanence and were last employed in 1974 by the Voorhees Township Jaycees.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

There is no formalized warning system in effect as the dam has not been overtopped since 1940. However, it is positioned on the muncipal boundary which could be the cause of possible jurisdictional problems.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

Present safeguards are deemed to be adequate in view of performance record and the lack of hazards relating to the dam. However, it is felt that the ownership responsibility of maintenance should be clarified in the future by local and state authorities notwithstanding the fact that the structure is presently operating satisfactorily.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In accordance with the criteria in the Recommended Guidelines for Safety Inspection of Dam, it has been determined that the dam at Kirkwood Lake is small in size and is placed in the significant hazard category. Accordingly, the spillway design flood (SDF) was selected by the inspection team to be the 100-year frequency event. The inflow hydrograph was calulated utilizing precipitation data from Technical Paper 40 and NOAA Technical Memorandum NWS Hydro-35. The inflow hydrograph and routing through the reservoir were performed by the HEC-1 computer program. Peak inflow to the reservoir was 4,505 cfs which when routed through the reservoir was reduced to 3,647 cfs. The spillway capacity before overtopping is approximately 918 cfs, thus the spillway will accommodate only 25% of the design flood.

b. Experience Data

Records indicate that the dam has been overtopped several times in the past. In December 1940, the dam was overtopped by 5 feet and the embankment failed in three places. There is a water quality gage located at the site. Original design calculations indicate a spillway capacity of 885 cfs and according to the Corps of Engineers, the Hydrology Coordinating Committee of the Delaware River Basin Commission has adopted a Q_{100} of 2,500 cfs at this site.

c. Visual Observations

It appears the dam is protected to a great degree by the highway embankment of White Horse Road.

d. Overtopping Potential

Employing the discharge and spillway capacities contained herein, overtopping of more than three

feet would occur in the event of the design storm. Moreover the dam has been overtopped several times in the past and thus it is felt there is considerable potential for future overtopping.

e. Drawdown

It would take approximately 13 hours to dewater the lake utilizing the 3' x 5' lower gate. The invert of this gate is 8.5' below the crest elevation and as previously reported, it could not be ascertained how the lower portions of the stoplogs could be pulled.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

The concrete spillway, although buttressed against the old stone masonry abutment walls is in no immediate danger of collapse unless the embankment is scoured out on each side. Further, during most severe flooding conditions, there is apparently a backwater condition caused by the partially-blocked elliptical CMP culvert under the roadway embankment just 100 feet downstream. However, surface run-off from the crest is slowly scouring out the backslope fill behind the bridge wingwalls and together with the two storm drains from the railroad property have created a stilling basin between the dam and the roadway embankment.

A major portion of the dam is of no structural concern as the downstream slopes are completely backfilled up to dam crest elevation and surcharged by the highway embankment.

b. Design and Construction Data

Sufficient design data was available from the 1941 Application permit to evaluate the concrete spillway. Little can be deduced relative to the structural stability of the old bridge abutments especially regarding the in-situ foundation conditions. It is very possible that the bridge is constructed on timber piling (in view of the lack of differential settlement). As long as the spillway is laterally braced by the bridge substructure, its structural condition is satisfactory.

c. Operating Records

No formal records exist. As previously stated, the spillway appears to have functioned satisfactorily as an uncontrolled outlet since its 1941 reconstruction. There are no recorded instances of overtopping since that date.

d. Post Construction Changes

There have been no modifications to the hydraulic elements since 1941. However, the surrounding area has undergone considerable change with the addition of the downstream highway embankment and bridge over the railroad, the addition of the railroad sidings, relocated trackage, marshalling yard drainage and the abandonment of the local street over the dam crest.

e. Seismic Stability

The bridge has an adequate factor of safety against static loadings and experience indicates that it will therefore have adequate stability against Seismic Zone 1 dynamic loadings.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Subject to the inherent limitations of the Phase I visual inspection, Kirkwood Lake Dam is classified as being in a sound and overall fair condition insofar as its embankment structure is concerned but the spillway bridge abutments at the main discharge outlet are in need of repair. No seriously detrimental findings were revealed in this inspection to render a questionable judgement as to the present structural stability. The concrete spillway is inadequate hydraulically, being able to accommodate approximately 25% of the 100 year design flood. The overtopping potential is considerable due to the hydraulically inadequate spillway and the ease with which the elliptical CMP outlet, 100 feet downstream, can be blocked with debris.

b. Adequacy of Information

The information gathered for the Phase I inspection is deemed to be adequate regarding the structural stability of the dam except for the lack of detailed information regarding the bridge foundations. No surveys or inspections have been recorded since 1961 and the dam has undergone deterioration since that time.

c. Urgency

It is recommended that the remedial measures set forth below be taken under advisement in the near future.

d. Necessity for Further Study

Due to the downgraded significant hazard classification and the fact that only moderate

downstream property damage is likely in case of a failure, further engineering studies, under the purview of the P.L. 92-367, are believed to be unnecessary.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that the ownership and responsibility for maintenance be clarified as a collapse could present a legal problem regarding responsibility.

a. Alternatives

- The downstream slopes of the dam embankment in the vicinity of the bridge wingwalls should be regraded, compacted and topped with suitable slope protection.
- The trees should be removed from the dam crest in the vicinity of the spillway and the disturbed areas regraded, compacted and seeded.
- Heavy stone should be placed in the downstream stilling basin in selected areas to prevent further scouring and preclude the undermining of the bridge structure.
- Patch the spalled and deteriorated concrete surfaces and stone masonry of the bridge walls.
- The crest width should be increased at each side of the spillway and seeded or protected from surface erosion.

b. O&M Maintenance and Procedures

The owners should upgrade O&M procedures by issuing check lists for periodic inspections and institute a system of record keeping for severe storms.

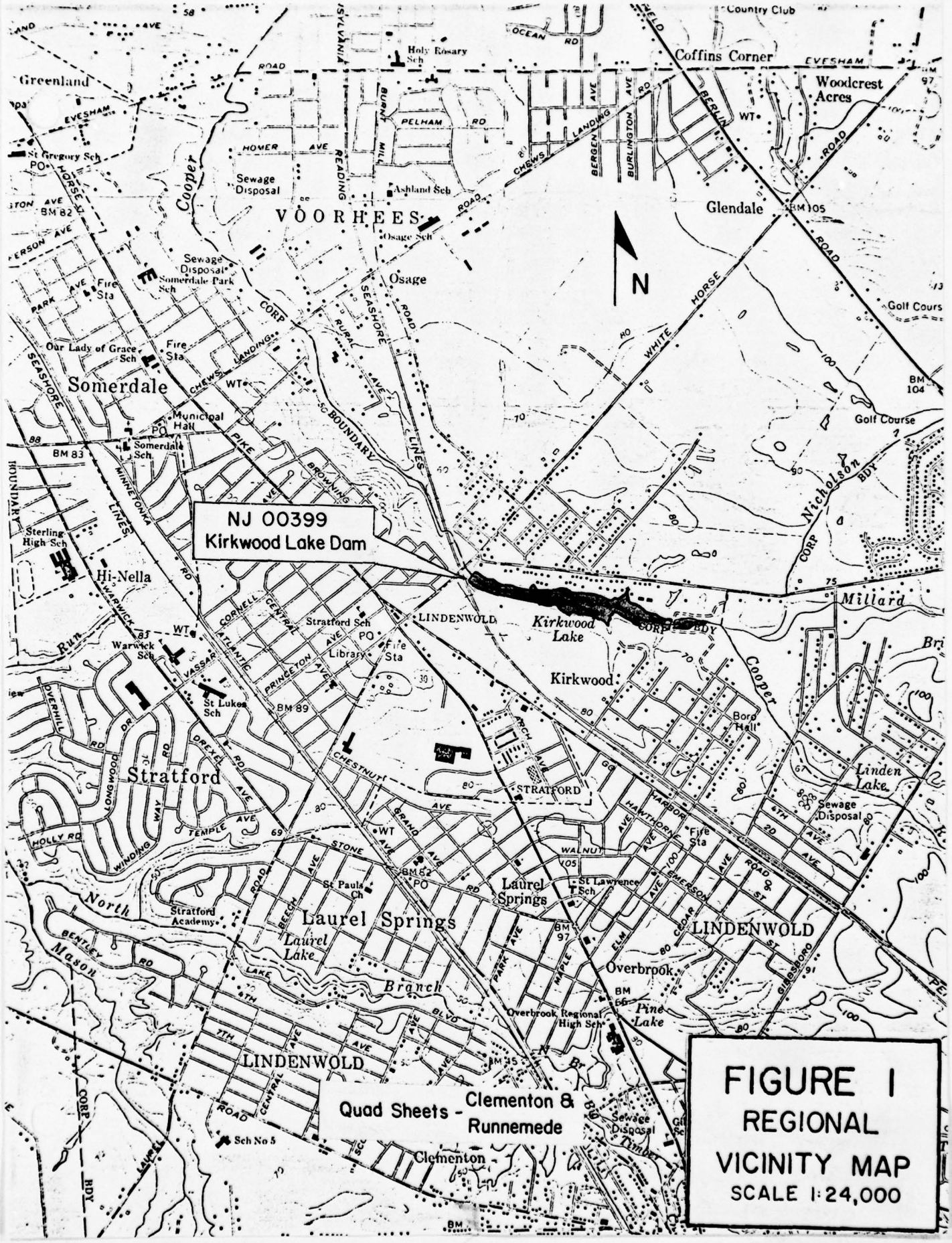
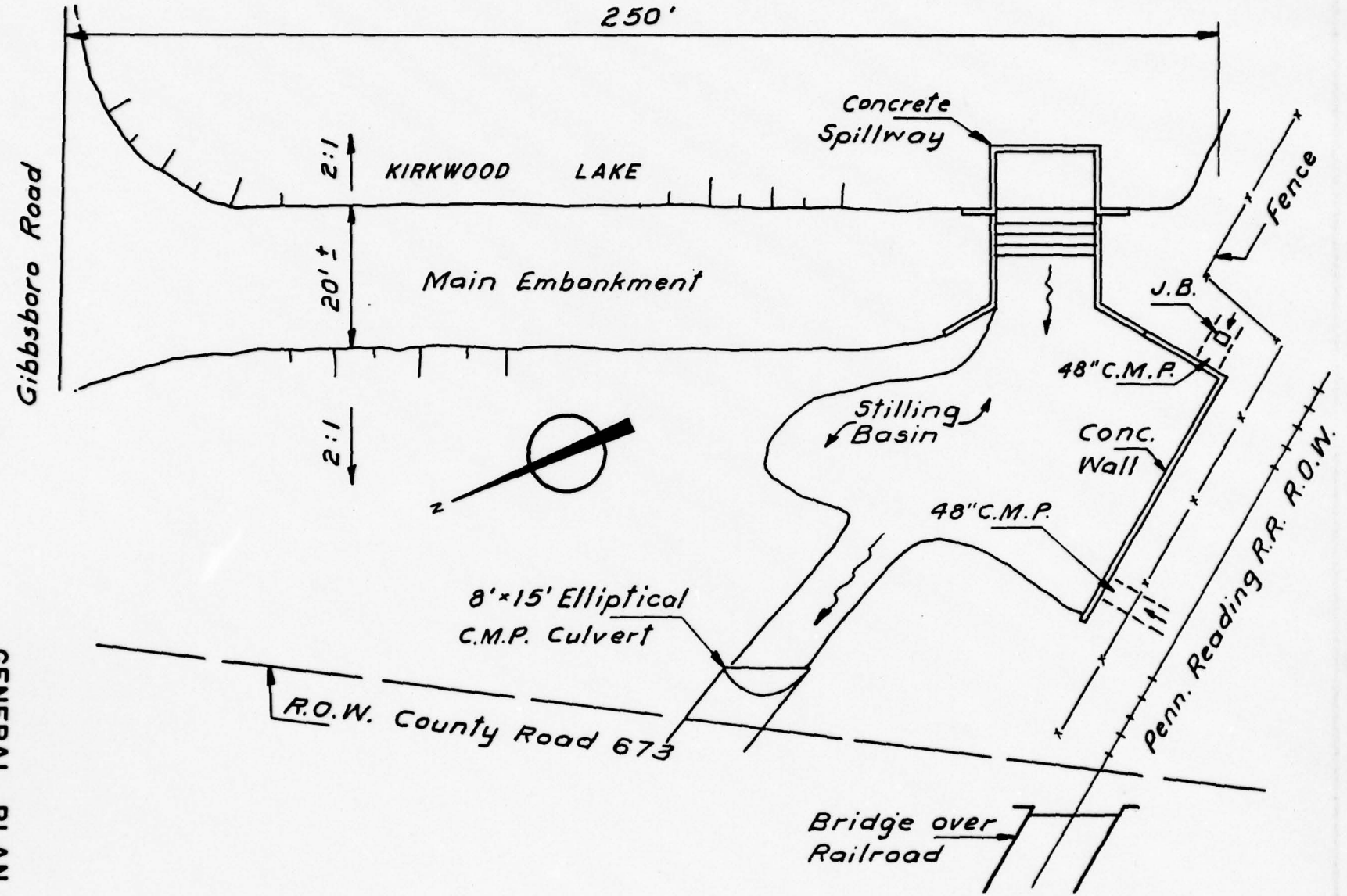
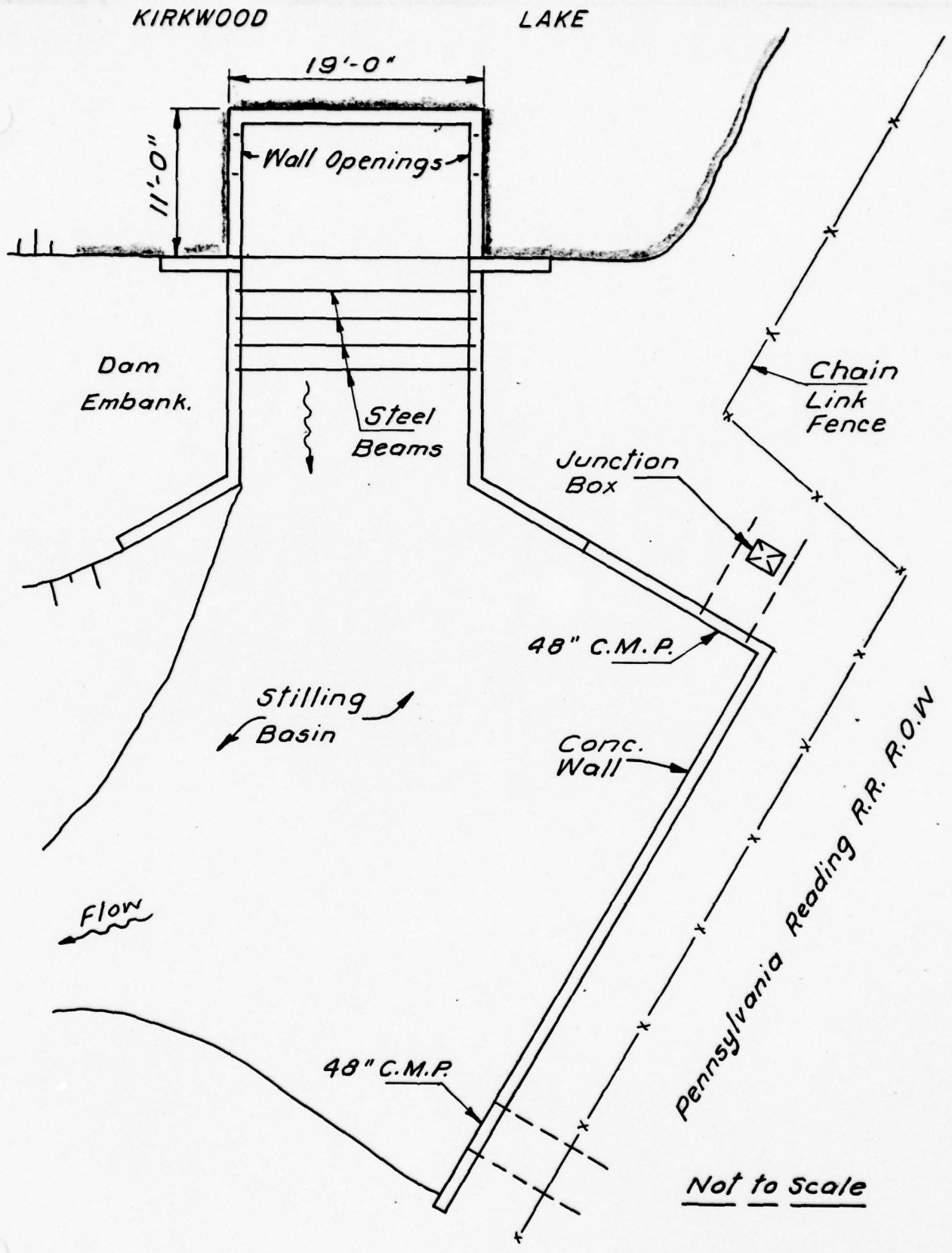


FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000



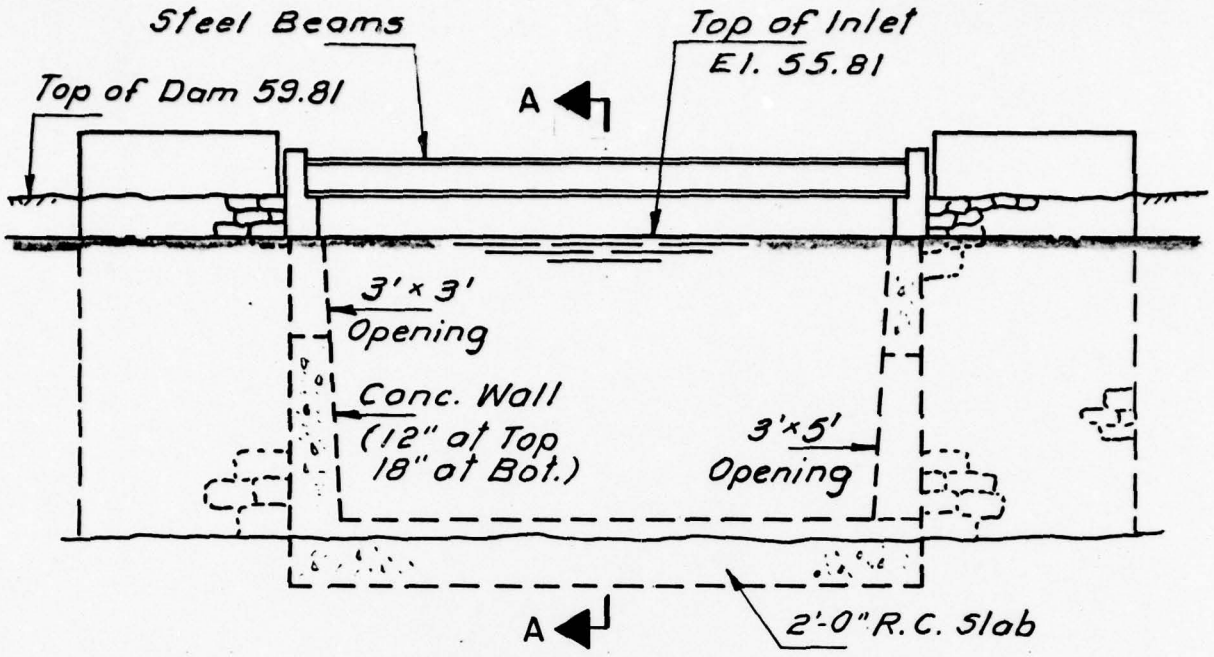
GENERAL PLAN

FIGURE 2



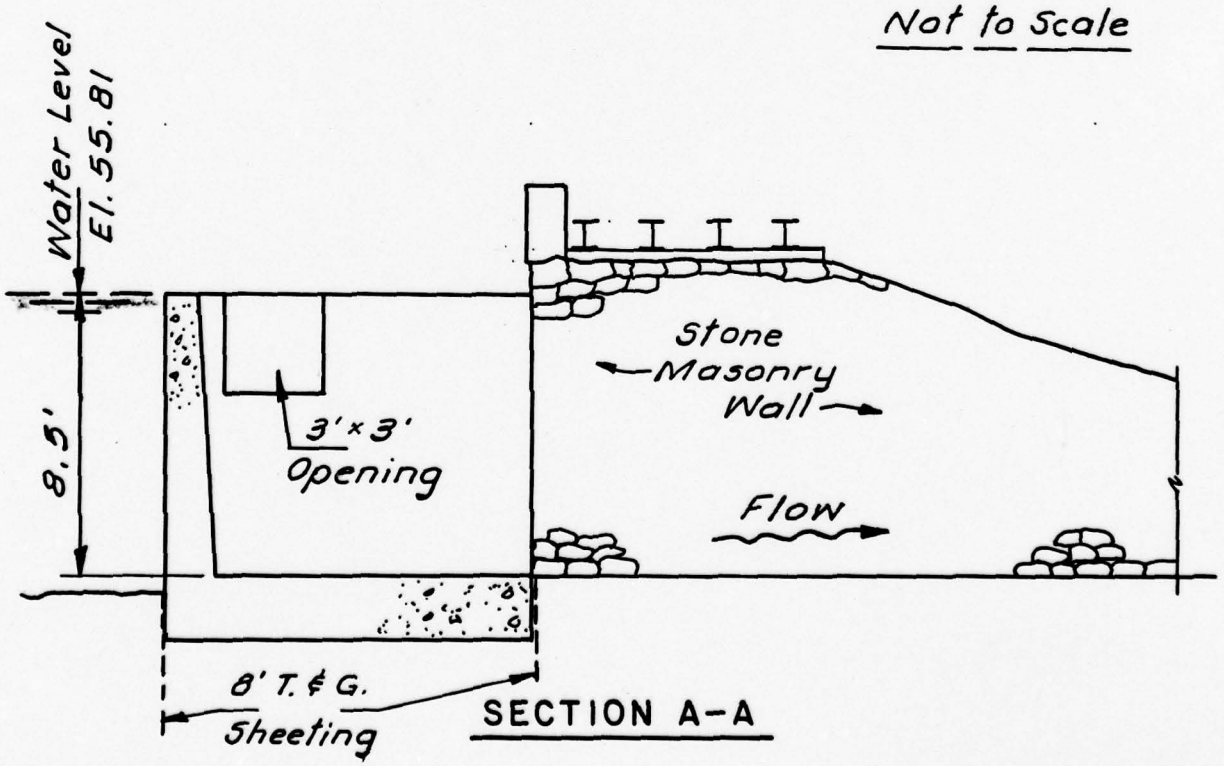
PLAN

FIGURE 3



INLET ELEVATION

Not to Scale



SECTION A-A

FIGURE 4

Check List
Visual Inspection
Phase 1

Name Dam Kirkwood Lake County Camden State New Jersey Coordinators NJDEP

Date(s) Inspection 1 May 79 Weather Clear Temperature 60 F

Pool Elevation at Time of Inspection 56± M.S.L. Tailwater at Time of Inspection 48± M.S.L.

Inspection Personnel:

K. Jolls L. Baines

E. Simone

K. Greenfield

L. Baines Recorder

CONCRETE/MASONRY DAMS
(SPILLWAY BRIDGE)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Satisfactory	Poorly defined abutment zone.
DRAINS	None	No visible method of dewatering lake except stop logs.
WATER PASSAGES	None	
FOUNDATION	No backslopes - top of dam is at toe of downstream roadway embankment Structural stability no problem.	West portion of embankment ill-defined.

CONCRETE/MASONRY DAMS
(Spillway Bridge)

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Concrete wingwalls are badly broken up and demolished	Much is beyond repair and should be replaced.
STRUCTURAL CRACKING	Severe (in masonry joints)	
VERTICAL AND HORIZONTAL ALIGNMENT	Poor - no regular geometry	Exposed steel I-beams over spillway (Superstructure missing)
MONOLITH JOINTS	None	
CONSTRUCTION JOINTS	None	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Observed Crest sand with trace of silt & clay (litle cohesion). No protection.	Top of dam grade very irregular. Eroded by dirt bike tracks and run-off from roadway slopes to the South.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed	Downstream toe covered by road embankment.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Embankment upstream slope to left of spillway very steep. Downstream slope severely eroded (towards headwall of drains under RR embankment.)	Slope paving required at wingwall swales.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Very irregular	Spillway is at low point on crest.
RIPRAP FAILURES	No riprap	Some small areas eroded on upstream slopes.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
EXCESSIVE SHRUB GROWTH, TREES, ETC.	Trees on upstream slope (do not remove except adjacent to spillway).	No discernible embankment (no downstream slopes except at elliptical pipe under roadway embankment.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Satisfactory	
ANY NOTICEABLE SEEPAGE	No	
STAFF GAGE AND RECORDER	None (re H & H)	Water quality gage.
DRAINS	One	

OUTLET WORKS (Spillway Bridge)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Old masonry walls along outlet. Masonry in very poor condition (badly spalled).	Concrete block placed over stone masonry in some areas.
INTAKE STRUCTURE	Concrete crest in satisfactory condition.	
OUTLET STRUCTURE		
OUTLET CHANNEL	Natural stilling basin between outlet & road embankment 100' west.	
EMERGENCY GATE	3'x5' gate bottom right of box spillway. Appears inoperable.	See plans for gate size on other wall (submerged)

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	11' x 19' concrete drop inlet (satisfactory condition)	Crest appears straight & true (no chipping or diff. settlement).
APPROACH CHANNEL	Main body of reservoir	
DISCHARGE CHANNEL	Clear	Flow discharges into CMP under highway embankment immediately downstream.
BRIDGE AND PIERS	See outlet works	Several water pipes at upstream face. (No manholes or connections located).

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	Water quality gage.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Flat, gentle slopes on right, with slightly steeper grade on left.	
SEDIMENTATION	Reservoir heavily silted up. (Lilies growing in some areas.) Shoreline well established. Heavily wooded right down to waters edge. Appears to have been cleaned periodically.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	8'x15' elliptical CMP under Rt.673 embankment. Railroad bridge further downstream (span-20'±, 5' freeboard) Channel parallels RR embankment.	1 or 2 feet of silt blocking CMP.
SLOPES	Flat, very irregular, wooded, undeveloped area. All homes above flood elevation	
APPROXIMATE NO. OF HOMES AND POPULATION	None	Only sewage plant in Somer dale could be affected.

Note:

Dam appears to have been overtopped just to the right of the spillway (possibly from surface drainage from RR yard.)

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available (NJDEP)
REGIONAL VICINITY MAP	Available (U.S.G.S. Quad)
CONSTRUCTION HISTORY	Available (NJDEP)
TYPICAL SECTIONS OF DAM	Not available
HYDROLOGIC/HYDRAULIC DATA	Some available (NJDEP and USGS)
OUTLETS - PLAN	Available (NJDEP) - partially
- DETAILS	Available (NJDEP)
-CONSTRAINTS	Not available
-DISCHARGE RATINGS	Not Available
RAINFALL/RESERVOIR RECORDS	Not Available

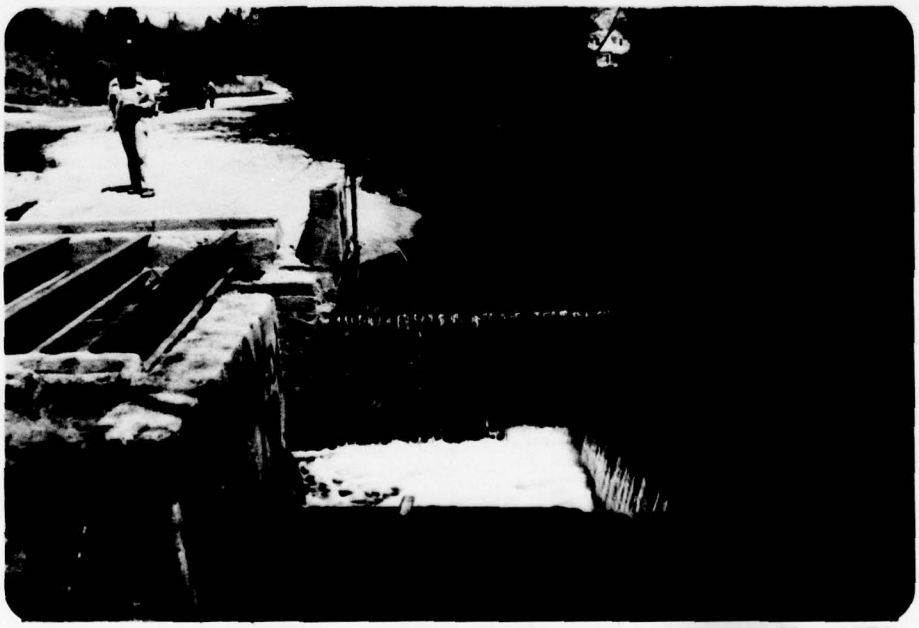
ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	None
DETAILS	None
OPERATING EQUIPMENT PLANS & DETAILS	None

ITEM	REMARKS
DESIGN REPORTS	Not Available
GEOLOGY REPORTS	Not available
DESIGN COMPUTATIONS	Not available
HYDROLOGY & HYDRAULICS	Not available
DAM STABILITY	Limited available (NJDEP)
SEEPAGE STUDIES	Not available
MATERIALS INVESTIGATIONS	Not available
BORING RECORDS	" "
LABORATORY	" "
FIELD	" "
POST-CONSTRUCTION SURVEYS OF DAM	Not available
BORROW SOURCES.	Not available

ITEM	REMARKS
MONITORING SYSTEMS	None
	None
MODIFICATIONS	
HIGH POOL RECORDS	None
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Available (partial)
PRIOR ACCIDENTS OR FAILURE OF DAM	Available (NJDEP) (partial)
DESCRIPTION	Available (NJDEP) (Partial)
REPORTS	Not available
MAINTENANCE OPERATION RECORDS	Some Available

May, 1979

View of Spillway Structure



May, 1979

May, 1979

View of CMP Under Rt. 673 Embankment

May, 1979

View of Stilling Basin

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 5.14 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): + 55.81 (92 AF)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): +59.81 (226 AF)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: + 59.81

CREST:

a. Elevation +59.81
b. Type Earth embankment
c. Width Varies
d. Length 250
e. Location Spillover None
f. Number and Type of Gates 2 sets of 3' 0" stoplogs

OUTLET WORKS:

a. Type 3-sided concrete drop inlet
b. Location left abutment
c. Entrance inverts +55.81
d. Exit inverts +47.3
e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES: None
a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 918 c.f.s.(spillway capacity)

BY D.J.M DATE 9-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A1 OF.
CHKD. BY DATE KIRKWOOD LAKE DAM PROJECT C234
SUBJECT

length of longest watercoorse = 2.3 miles = 12,144 ft.
$\Delta H = 40'$

$$\therefore t_c = \left(\frac{11.9 \times 2.3^3}{40}\right)^{0.385} = 1.64 \text{ hours}$$

Alternate method:

$$\text{Slope along watercourse} = \frac{40 \times 100}{12,144} = 0.33$$

Assume velocity $= 1.5 \text{ ft. s}^{-1}$

$$\therefore t = \frac{12144}{1.5 \times 3600} = 2.25 \text{ hours}$$

Overland flow $\quad \text{Slope} = \frac{80 \times 100}{2000} = 4\%$

Assume velocity $= 2 \text{ ft. s}^{-1}$

$$\therefore t' = \frac{2000}{2 \times 3600} = 0.28 \text{ hours}$$

$$\therefore t_c = t + t' = 2.53 \text{ hours}$$

Use $t_c = 2.1$ hours

$$\therefore t_p = \frac{0.25}{2} + 0.6 \times 2.1 = 1.39 \text{ hours}$$

$$Q_p = \frac{484 \times 5.14}{1.39} = 1790 \text{ cfs}$$

BY D.J.M DATE 9-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A2 OF
CHKD. BY ____ DATE ____ KIRKWOOD LAKE DAM PROJECT C-234
SUBJECT ____

Unitgraph:

Time (hours)	T/Tp	Dimensionless Ordinate (DO)	Q (cfs) = Qp x DO
0.25	0.18	0.06	107
0.50	0.36	0.22	394
0.75	0.54	0.49	877
1.00	0.72	0.79	1414
1.25	0.90	0.97	1736
1.50	1.08	0.99	1772
1.75	1.26	0.87	1557
2.00	1.44	0.71	1271
2.25	1.62	0.54	966
2.50	1.80	0.42	752
2.75	1.98	0.32	573
3.00	2.16	0.25	447
3.25	2.34	0.19	340
3.50	2.52	0.14	251
3.75	2.70	0.11	197
4.00	2.88	0.08	143
4.25	3.06	0.06	107
4.50	3.24	0.05	89
4.75	3.42	0.04	72
5.00	3.60	0.03	54
5.25	3.78	0.025	45
5.50	3.96	0.019	34

BY D J M DATE 6-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A3 OF
CHKD. BY DATE SOUTH GROUP DAMS PROJECT C 234
SUBJECT

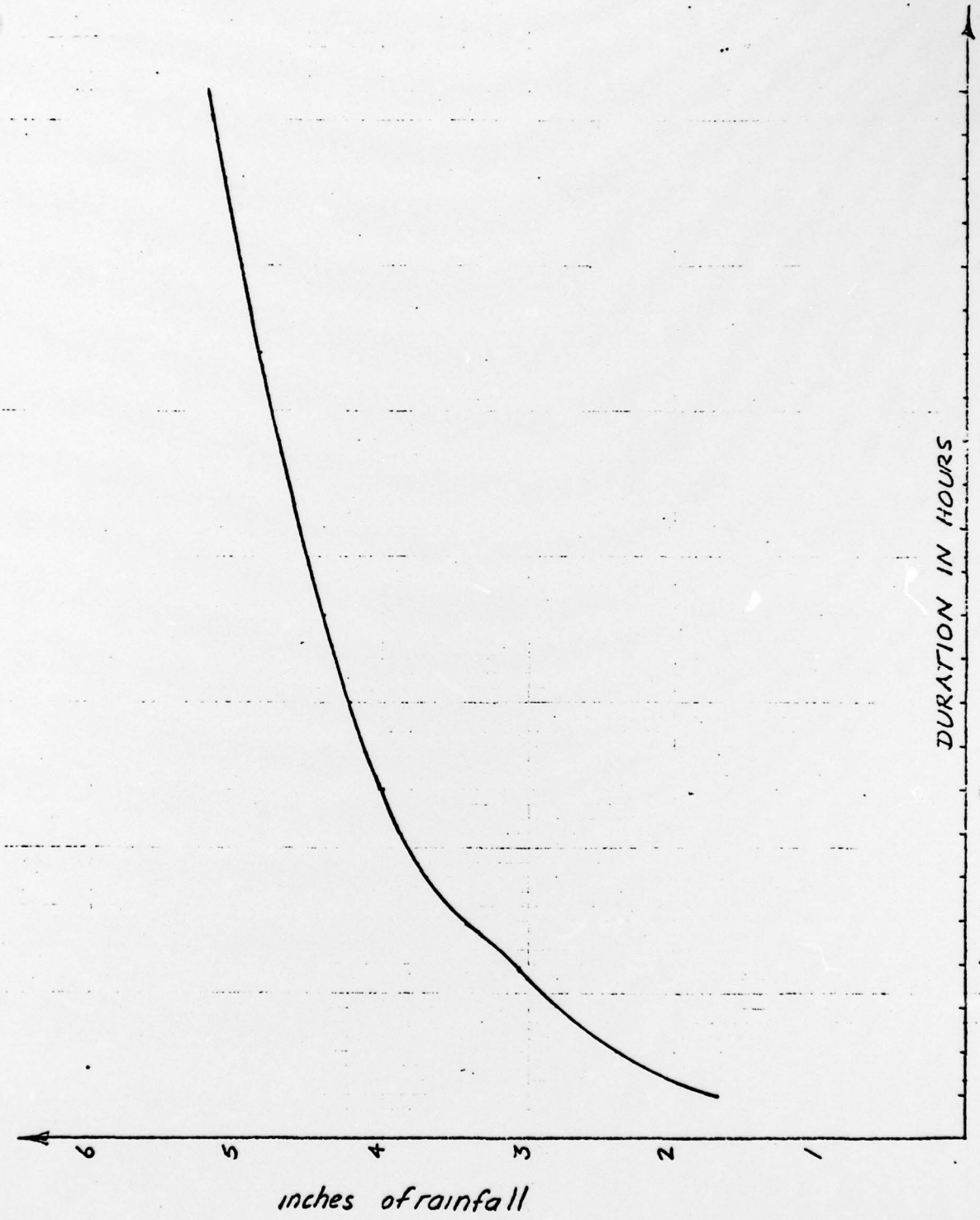
Precipitation data from T.P. 40 & NOAA Technical Memorandum NWS HYDRO-35 (See depth duration curve overleaf)

Time	Precipitation	Δ	Rearrange Δ
0.25	1.7	1.7	0.06
0.50	2.4	0.7	0.06
0.75	2.8	0.4	0.06
1.00	3.1	0.3	0.07
1.25	3.4	0.3	0.08
1.50	3.7	0.3	0.09
1.75	3.86	0.16	0.11
2.00	4.00	0.14	0.14
2.25	4.11	0.11	0.30
2 50	4.22	0.11	0.30
2.75	4.31	0.09	0.70
3 00	4.40	0.09	1.70
3.25	4.49	0.09	0.40
3.50	4.57	0.08	0.30
3.75	4.64	0.07	0.16
4.00	4.71	0.07	0.11
4.25	4.78	0.07	0.09
4.50	4.84	0.06	0.09
4.75	4.90	0.06	0.07
5.00	4.96	0.06	0.07
5.25	5.02	0.06	0.06
5.50	5.08	0.06	0.06
5.75	5.14	0.06	0.06
6.00	5.20	0.06	0.06

BY D.J.M. DATE 1-11 SUBJECT SHEET NO. OF A4

CHKD. BY DATE DEPTH DURATION CURVE JOB NO. C227

T.P. 40 & NOAA Tech. Memo NWS - HYRO 35



BY. D.J.M. DATE 6-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A5 OF.

CHKD. BY. DATE KIRKWOOD LAKE DAM PROJECT 6234

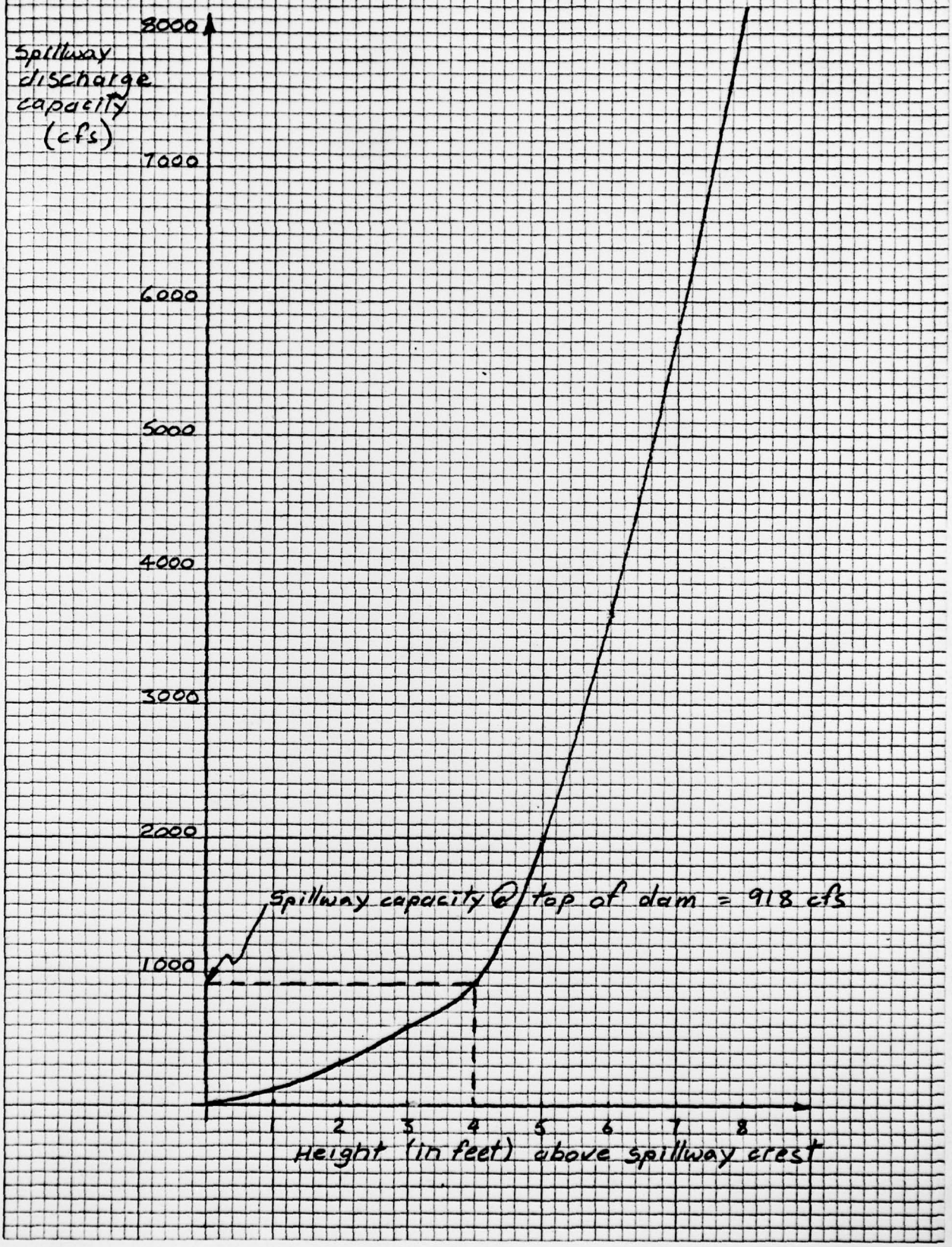
SUBJECT Spillway discharge capacity

Spillway discharge :

flow over spillway crest L = 37'			flow over dam L = 250'			ΣQ (cfs)
H	C	Q	H	C	Q	
1	3.1	115				115
2	3.1	324				324
3	3.1	596				596
4	3.1	918	0	2.8	0	918
5	3.1	1282	1	2.8	700	1982
6	3.1	1686	2	2.8	1980	3666
7	3.1	2124	3	2.8	3637	5761
8	3.1	2595	4	2.8	5600	8195

The spillway capacity calculated above does not include the two low level openings built into the sides of the spillway structure. As there is no guarantee that they will be open under flood conditions.

KIRKWOOD LAKE DAM
STAGE DISCHARGE CURVE

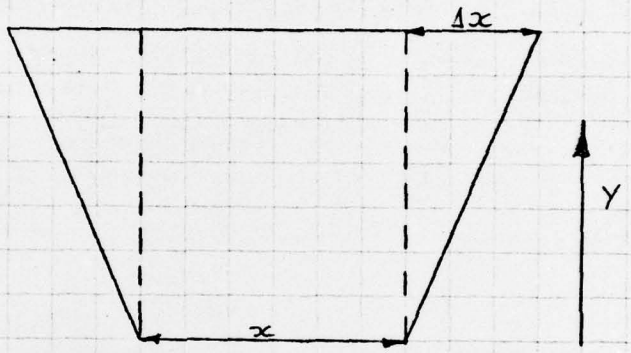


BY D.J.M. DATE 6-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A7 OF
CHKD. BY DATE KIRKWOOD LAKE DAM PROJECT C234
SUBJECT

Surcharge storage:

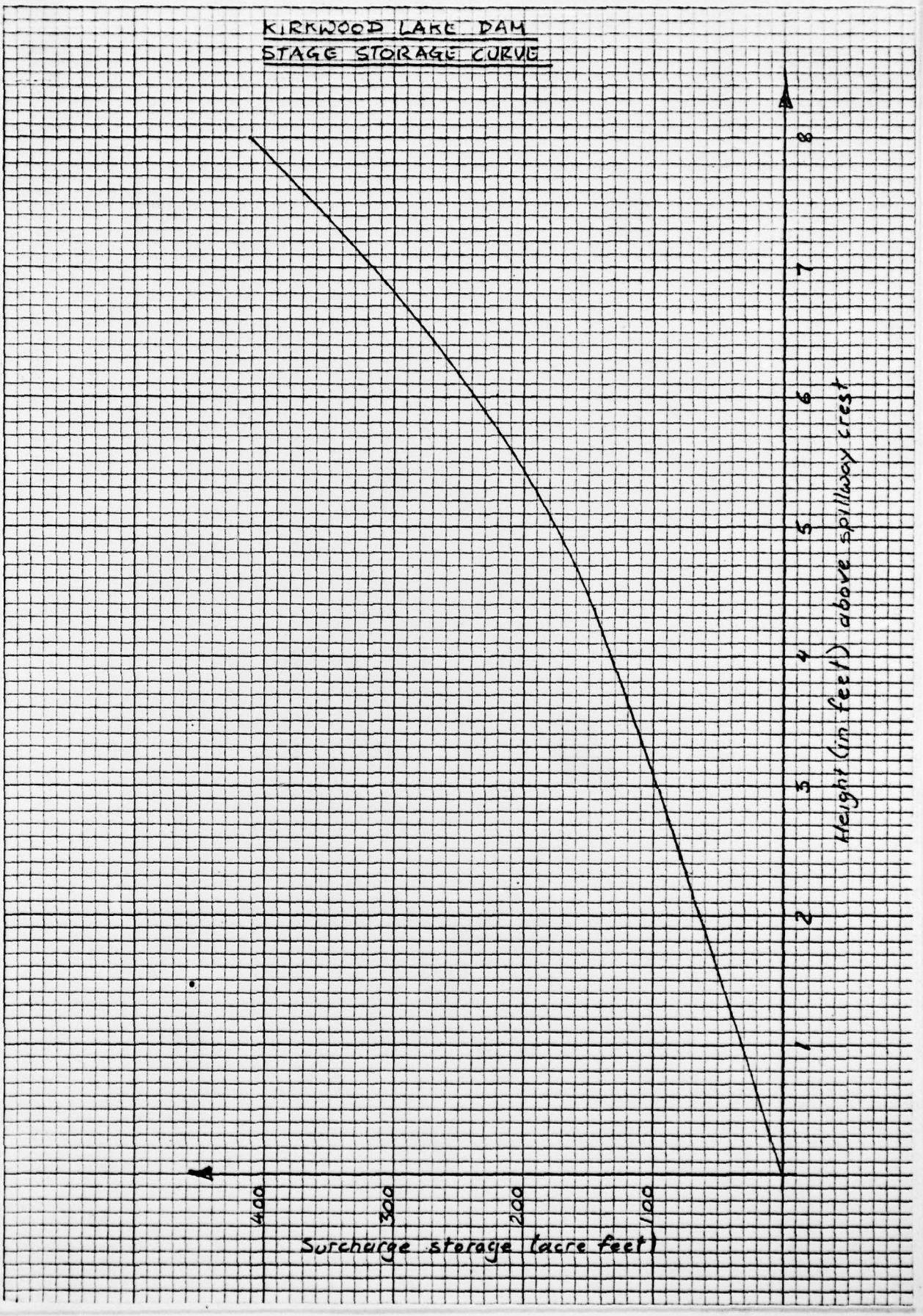
Area of lake @ El. 55.81 = 31 acres

Area of 70' contour = 217.1 acres



Increment in volume $\Delta V = (x + \Delta x) Y$

Height in feet above spillway crest (feet)	Surcharge storage (acre feet)
0	
1	32
2	65
3	99
4	134
5	177
6	237
7	315
8	411



BY D.J.M. DATE 7-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 19 OF

CHKD. BY DATE KIRKWOOD LAKE DAM PROJECT C 234

SUBJECT Approximate drawdown Calculation

Available head ≈ 8.5'

Storage @ normal pool = 92 acre feet

Assume drawdown in two equal stages with no inflow or tailwater conditions.

stage i)

$H = 6.4'$

$Q \approx 117$ cfs

$$\therefore \text{time} \approx \frac{92 \times 43560}{117 \times 2 \times 3600}$$

$$= 4.76 \text{ hours}$$

stage ii)

$H = 2.13'$

$Q = 68$ cfs

$$\therefore \text{time} \approx \frac{92 \times 43560}{2 \times 68 \times 3600}$$

$$= 8.19 \text{ hours}$$

$$\Sigma \text{ time} = (4.76 + 8.19) \approx 13 \text{ hours}$$

LOUIS BERGER & ASSOCIATES INC.

KIRKWOOD LAKE DAM

KIRKWOOD LAKE DAM
BY D.J.M.
JUNE 21 1979

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	0	15	0	0	0	0	0	0	0

JOPER	NWT
3	0

********** *********** ********** ********* **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	-1	5.14	0.0	5.14	0.0	0.0	0	0	0

PRECIP DATA

NP	STORM	DAJ	CAK
24	0.0	0.0	0.0

PRECIP PATTERN

0.06	0.06	0.06	0.07	0.08	0.09	0.11	0.14	0.30	0.30
0.70	1.70	0.40	0.30	0.16	0.11	0.09	0.09	0.07	0.07
0.06	0.06	0.06	0.06						

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	1.50	0.33	0.0	0.0

GIVEN UNIT GRAPH, NUHGG= 22

107.	394.	877.	1414.	1736.	1772.	1557.	1271.	966.	752.
573.	447.	340.	251.	197.	143.	107.	89.	72.	54.
45.	34.								

UNIT GRAPH TOTALS 13198. CFS OR 1.00 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q
1	0.06	0.00	0.
2	0.06	0.00	0.
3	0.06	0.00	0.
4	0.07	0.00	0.
5	0.08	0.00	0.
6	0.09	0.00	0.
7	0.11	0.00	0.
8	0.14	0.00	0.

9	0.30	0.00	0.
10	0.30	0.00	0.
11	0.70	0.42	45.
12	1.70	1.62	339.
13	0.40	0.33	1043.
14	0.30	0.23	2171.
15	0.16	0.09	3409.
16	0.11	0.04	4259.
17	0.09	0.02	4505.
18	0.09	0.02	4188.
19	0.07	0.00	3592.
20	0.07	0.00	2894.
21	0.06	0.00	2304.
22	0.06	0.00	1796.
23	0.06	0.00	1401.
24	0.06	0.00	1072.
25	0.0	0.0	810.
26	0.0	0.0	622.
27	0.0	0.0	462.
28	0.0	0.0	351.
29	0.0	0.0	279.
30	0.0	0.0	221.
31	0.0	0.0	171.
32	0.0	0.0	138.
33	0.0	0.0	95.
34	0.0	0.0	31.
35	0.0	0.0	16.
36	0.0	0.0	6.
37	0.0	0.0	3.
38	0.0	0.0	1.
39	0.0	0.0	1.
40	0.0	0.0	0.
41	0.0	0.0	0.
42	0.0	0.0	0.
43	0.0	0.0	0.
44	0.0	0.0	0.
45	0.0	0.0	0.
46	0.0	0.0	0.
47	0.0	0.0	0.
48	0.0	0.0	0.
49	0.0	0.0	0.
50	0.0	0.0	0.
51	0.0	0.0	0.
52	0.0	0.0	0.
53	0.0	0.0	0.
54	0.0	0.0	0.
55	0.0	0.0	0.
56	0.0	0.0	0.
57	0.0	0.0	0.
58	0.0	0.0	0.
59	0.0	0.0	0.
60	0.0	0.0	0.
61	0.0	0.0	0.
62	0.0	0.0	0.
63	0.0	0.0	0.
64	0.0	0.0	0.
65	0.0	0.0	0.
66	0.0	0.0	0.
67	0.0	0.0	0.
68	0.0	0.0	0.
69	0.0	0.0	0.

70	0.0	0.0	0.
71	0.0	0.0	0.
72	0.0	0.0	0.
73	0.0	0.0	0.
74	0.0	0.0	0.
75	0.0	0.0	0.
76	0.0	0.0	0.
77	0.0	0.0	0.
78	0.0	0.0	0.
79	0.0	0.0	0.
80	0.0	0.0	0.
81	0.0	0.0	0.
82	0.0	0.0	0.
83	0.0	0.0	0.
84	0.0	0.0	0.
85	0.0	0.0	0.
86	0.0	0.0	0.
87	0.0	0.0	0.
88	0.0	0.0	0.
89	0.0	0.0	0.
90	0.0	0.0	0.
91	0.0	0.0	0.
92	0.0	0.0	0.
93	0.0	0.0	0.
94	0.0	0.0	0.
95	0.0	0.0	0.
96	0.0	0.0	0.
97	0.0	0.0	0.
98	0.0	0.0	0.
99	0.0	0.0	0.
100	0.0	0.0	0.
SUM	5.20	2.77	36225.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4505.	1508.	377.	362.	36224.
INCHES		2.73	2.73	2.73	2.73
AC-FT		748.	749.	749.	749.

HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
11	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE=	0.	32.	65.	99.	134.	177.	237.	315.	411.	0.
OUTFLOW=	0.	115.	324.	596.	918.	1982.	3666.	5761.	8195.	0.

TIME	EOP STOR	AVG IN	EOP OUT
1	0.	0.	0.
2	0.	0.	0.

LOUIS BERGER & ASSOCIATES INC.

KIRKWOOD LAKE DAM

3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.
11	0.	22.	2.
12	4.	192.	15.
13	18.	691.	64.
14	48.	1607.	216.
15	97.	2790.	583.
16	156.	3834.	1452.
17	203.	4382.	2714.
18	229.	4347.	3448.
19	236.	3890.	3647.
20	230.	3243.	3465.
21	216.	2599.	3076.
22	200.	2050.	2615.
23	183.	1598.	2158.
24	168.	1237.	1766.
25	155.	941.	1430.
26	143.	716.	1139.
27	133.	542.	909.
28	124.	406.	822.
29	114.	315.	734.
30	105.	250.	650.
31	96.	196.	574.
32	88.	154.	510.
33	81.	116.	450.
34	73.	63.	391.
35	66.	24.	335.
36	60.	11.	293.
37	54.	5.	257.
38	50.	2.	226.
39	45.	1.	198.
40	41.	0.	174.
41	38.	0.	153.
42	35.	0.	134.
43	32.	0.	117.
44	30.	0.	108.
45	28.	0.	100.
46	26.	0.	93.
47	24.	0.	86.
48	22.	0.	80.
49	21.	0.	75.
50	19.	0.	69.
51	18.	0.	64.
52	17.	0.	60.
53	15.	0.	55.
54	14.	0.	51.
55	13.	0.	48.
56	12.	0.	44.
57	11.	0.	41.
58	11.	0.	38.
59	10.	0.	35.
60	9.	0.	33.
61	9.	0.	31.
62	8.	0.	28.
63	7.	0.	26.

64	7.	0.	24.
65	6.	0.	23.
66	6.	0.	21.
67	5.	0.	20.
68	5.	0.	18.
69	5.	0.	17.
70	4.	0.	16.
71	4.	0.	15.
72	4.	0.	13.
73	3.	0.	13.
74	3.	0.	12.
75	3.	0.	11.
76	3.	0.	10.
77	3.	0.	9.
78	2.	0.	9.
79	2.	0.	8.
80	2.	0.	7.
81	2.	0.	7.
82	2.	0.	6.
83	2.	0.	6.
84	2.	0.	6.
85	1.	0.	5.
86	1.	0.	5.
87	1.	0.	4.
88	1.	0.	4.
89	1.	0.	4.
90	1.	0.	4.
91	1.	0.	3.
92	1.	0.	3.
93	1.	0.	3.
94	1.	0.	3.
95	1.	0.	2.
96	1.	0.	2.
97	1.	0.	2.
98	1.	0.	2.
99	1.	0.	2.
100	0.	0.	2.
SUM			36202.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3647.	1402.	377.	362.	36202.
INCHES		2.54	2.73	2.73	2.73
AC-FT		695.	748.	748.	748.

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RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	4505.	1508.	377.	362.	5.14
ROUTED TO	11	3647.	1402.	377.	362.	5.14